Care and resuscitation of the newborn infant

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Care and Resuscitation of the Newborn Infant

Revised Recommendations of the Swiss Society of Neonatology (2012)

Elaborated by a working group of the Swiss Society of Neonatology consisting of (in alphabetical order): T. M. Berger, Lucerne; V. Bernet, Zurich; J.-C. Fauchère, Zurich; B. Laubscher, Neuchâtel; A. Malzacher, St. Gallen; M. Nelle, Bern; R. E. Pfister, Geneva; M. Roth-Kleiner, Lausanne; S. Schulzke, Basel; G. Zeilinger, Aarau; and D. Surbek*, Bern

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Introduction

Development and Application of these Recommendations

A working group of the Swiss Society of Neonatology (SSN) published national recommendations on the care and resuscitation of the newborn infant in 2000. Following a first update in 2007, the current paper represents a revision of these recommendations based on new data and evidences[1], and revised international guidelines[2)-7)]. These recommendations should be considered as guidelines that can and should be adapted as the individual situation requires.

Aim and Target Audience of these Recommendations

These recommendations primarily pertain to the care of neonates with a gestational age (GA) > 34 0/7 weeks and a birth weight (BW) > 2000 g. They apply to both delivery room care and the entire perinatal period. They address all obstetric units in Switzerland as well as all paediatricians, neonatologists, obstetricians, anaesthetists, midwives, and neonatal nurses.

Important changes in this revision

The following changes have been incorporated since the last revision in 2007:

- Delayed cord clamping 60 seconds post delivery should be employed in all vaginally born neonates not requiring resuscitation, provided there is no maternal indication for immediate cord clamping.
- In preterm neonates born by caesarean section, the cord should be milked 3 to 4 times towards the infant prior to cord clamping.
- Term neonates should primarily be resuscitated using room air. If oxygen saturation (measured by preductal pulse oximetry) remains below target despite adequate ventilation, supplemental oxygen administration should be considered. The aim is to achieve a normal postnatal rise in oxygen saturation *(Algorithm)*.
- Adrenaline should be applied intravenously whenever possible. In case of intratracheal application, a dose of 50–100 µg/kg should be given.
- Detection of expiratory CO_2 as an add-on to clinical assessment (auscultation, inspection of chest movement) is the fastest and most reliable method to confirm endotracheal placement of the tube.
- Neonates ≥ 36 weeks GA with clinical evidence of moderate to severe hypoxic ischaemic encephalopathy should receive therapeutic hypothermia in a perinatal centre. Heat sources (radiant warmer, warming bed) should only be turned off after consultation with the receiving centre until arrival of the transport team.

Organisation

General Aspects

Up to 10 % of all neonates require stabilisation measures such as simple respiratory support within the first minutes of life. More complex resuscitation measures are needed in only about 1 % of newborn infants[3) 8)]. Trained personnel and specific technical equipment must be readily available at every delivery because risk situations cannot always be predicted.

Requirements for Optimal Care of the Newborn Infant

- **Communication** between midwives, obstetricians and paediatricians (neonatologists).
- **Sufficient information** about the risks for the newborn infant, available already before delivery.
- **Anticipation** of problems that may arise.
- Careful **planning** and preparation of equipment and briefing of personnel.
- Clear and calm **leading of the resuscitation** by a competent professional who is trained in neonatal resuscitation.

Personnel

Ideally, one person is in charge of exclusively caring for the newborn infant after delivery. This person should be able to initiate a resuscitation, i.e. to open the airways and perform bag-and-mask ventilation. For further measures, especially for endotracheal intubation, help from a professional with experience in neonatal resuscitation (neonatologist, paediatrician, anaesthetist) must be requested[3), 5)].

Even after a low-risk delivery, the neonate may present with unforeseen problems. Therefore, each and every delivery unit needs to provide a well-functioning resuscitation table with specific equipment *(List 1)*, and a person with experience in neonatal resuscitation should be readily available. Primary responsibility for the neonate in the delivery room lies with the obstetrician; in individual cases, he may delegate this responsibility to a colleague from a different specialty, preferably to a paediatrician or neonatologist. Ideally, planned home birth should be organised such that there is one person caring for the labouring mother and another person with experience in neonatal resuscitation looking after the neonate[5)]. Physicians, midwives, and nurses caring for neonates after delivery should regularly attend structured courses in neonatal resuscitation[9)]. Local neonatal centres will organise and run such courses in the name of the Swiss Society of Neonatology.

Equipment

Checklists with equipment required for hospital or home delivery are given in the appendix *(Lists 1 and 2)*.

Prenatal Transfer of High-Risk Pregnant Women

Delivery of certain high-risk pregnant women requires specialised knowledge, skills, and equipment in view of optimal care of mother and infant. These requirements cannot be met in all delivery units due to differences in case load, experience and economic costs. Thus, a small proportion of pregnant women will need transfer to a perinatal centre with a neonatal intensive care unit well before a planned or impending delivery.

* Swiss Society of Gynaecology and Obstetrics

Indications for Prenatal Transfer

Intrauterine transport of the fetus to a perinatal centre is indicated in all cases of anticipated postnatal resuscitation or neonatal intensive care for the newborn infant.

A) Absolute indications include:

- Impending delivery before 32 0/7 weeks of gestation.
- If no neonatal unit within the delivery hospital: Impending delivery before 34 0/7 to 35 0/7 weeks of gestation or estimated fetal weight < 2000 g; otherwise this is a relative indication.
- Anticipated difficulties in adaptation requiring intensive care.
- Multiple pregnancy (≥ triplets).
- Prenatally diagnosed malformation requiring immediate postnatal intervention.

B) Relative indications include(if in doubt, and depending on local circumstances, the closest perinatal centre should be consulted)

- Intrauterine infection.
- Haemolytic disease of the fetus.
- Fetal arrhythmia.
- Intrauterine growth retardation (estimated fetal weight <5th percentile).
- Chronic or unstable illness of the mother (e.g. hypertension, pre-eclampsia, HELLP-syndrome, diabetes mellitus, status post organ transplant, autoimmune disease, etc.).
- Maternal substance abuse.
- Fetus with a lethal malformation where intensive care is not considered meaningful.

Neonatal Adaptation

Introduction

Transition from intrauterine to extrauterine life requires a number of biological adaptive steps that are especially important for the integral functioning of the central nervous system. However, delivery and the first days of life are also an emotional event, profoundly influencing the future of the parent-infant relationship. Perinatal care needs to consider these adaptive and emotional processes and weight them appropriately.

Preparation for Delivery Room Management

- Preheat delivery room (ideally to 25°C).
- Switch on radiant warmer and light.
- Read maternal medical notes and evaluate if additional experienced personnel might be required.
- Check equipment.
- Wash hands and wear non-sterile gloves.
- Start Apgar timer or stop watch after complete delivery of the infant[10].

Cord Clamping

Delayed cord clamping 60 seconds post delivery and positioning of the infant about 20–30 cm below the vaginal introitus may result in placento-neonatal transfusion in vaginally delivered preterm and term neonates who do not require postnatal resuscitation and whose mothers do not need urgent clamping of the cord (e.g., no maternal haemorrhage), and especially in newborn infants at risk of hypovolaemia (e.g., after vacuum extraction or breech presentation)[a), 3), 5), 11), 12)].

Clinical Assessment of Adaptation

The following 4 criteria are decisive for subsequent resuscitation measures *(Algorithm)*:

- *Respiration:* Present or absent? Gasping? Usually, healthy term neonates start breathing or crying within 60 seconds following delivery.
- *Heart rate:* Preferably, measure heart rate via auscultation using a stethoscope or by palpating for pulsations at the base of the umbilical cord. Is heart rate above 60 or above 100 beats per minute, respectively? Palpating peripheral pulses is not useful for determining heart rate[6].
- *Tone:* A neonate presenting with very low muscle tone very likely requires respiratory support[5].
- *Skin colour:* Is the infant centrally pinking up? Most neonates are initially pale to cyanotic as fetal SaO_2 is around 40–60% and skin perfusion is still diminished. After a few minutes, skin colour changes to a generalised pink. Assessing oxygenation by skin colour can be difficult[18]. Central cyanosis in the presence of anaemia is only visible at very low levels of oxygen saturation. If a neonate remains cyanotic after birth, oxygenation should be assessed using pulse oximetry at the latest with 5 minutes of life[5]. On the other hand, very pale skin colour can be a good indicator of anaemia or acidosis requiring treatment[5].

Apgar Score

The Apgar Score is a standardised evaluation of postnatal transition and of the success of any resuscitation measures. However, the Apgar Score is inappropriate for making therapeutic decisions.

At 1, 5, and 10 minutes after complete delivery of the infant, every item of the Apgar Score is evaluated and the numbers recorded in the infant's chart. In case of clinical changes or after therapeutic measures, additional Apgar Scores may be obtained during the 10 minutes following birth or even beyond these first 10 minutes[5].

Procedures During Normal Adaptation

- Neonates normally breathe spontaneously after delivery, have a heart rate above 100 beats/minute, present with a good muscle tone, and become pink within 5 to 10 minutes following birth[19), 20)]. This newborn infant is quickly dried with warmed blankets and is laid on the mother's belly.
- Not every infant needs to be suctioned. If a term newborn infant breathes within the first 60 seconds of life, shows good muscle tone, and if the amniotic fluid is clear, then suctioning of the mouth and pharynx are not warranted. Unnecessary suctioning is uncomfortable for the infant, can cause damage to the mucous membranes, and even lead to reflex bradycardia and apnoea.
- The Apgar Score is assessed at 1, 5 and 10 minutes of life.
- Shortly after delivery the neonate is encouraged to have a first breastfeed.

Ideally, mother and infant are allowed continuous skin-to-skin contact for 2 hours after delivery; at minimum, skin-to-skin contact should be allowed until after the first breastfeed. Simultaneously, the attending midwife or nurse should periodically check up on the well-being of the infant[21]. It is of particular importance to keep the mouth and nose free of any obstruction when a baby is placed on

a) With regard to delayed cord clamping, culturally embossed different and individual wishes of the mother regarding clamping time should also be considered. Delayed cord clamping in premature infants is associated with a higher mean blood pressure and haematocrit, as well as with a lower incidence of cerebral haemorrhage, but not necessarily with a better stability within the first 4–6 hours of life[13)-16)]. This is why no recommendation or concrete time to clamp the cord can be stated when resuscitation is needed[3), 5)]. In term infants delivered by Caesarean section, the cord is clamped immediately after the extraction of the newborn infant. Preterm infants, the cord can be milked three to four times toward the neonate before clamping[17)]. With regard to use oxytocin before clamping the cord in deliveries by Caesarean section, the available data are unclear concerning the optimal time, dose and efficacy.

	0	1	2
Skin colour	Trunk blue or pale	Trunk pink but extremities blue	Completely pink
Respiratory effort*	Absent	Superficial	Good, crying
Muscle tone	Flaccid	Some flexion of extremities	Well flexed extremities
Reactivity**	No response	Slow	Vigorous
Heart rate	0	< 100/Min.	> 100/Min.

Apgar-Score * Caveat: Assess respiratory effort in ventilated infants with a dash (-).
** Reactivity: Spontaneous motor activity, crying, sneezing, coughing

the mother's chest. Routine procedures and further care of the infant should be performed about 2 hours after delivery, or after the first breastfeed at the earliest[22]. These procedures include a first general exam by the midwife, obstetrician, paediatrician, or neonatologist. This exam should be done under a radiant warmer in good lighting conditions.
The purpose of this first exam is to assess the further adaptation and body measurements, and to exclude potential malformations:

- **Body measurements:** weight, length, head circumference (plot values on a growth chart)[23].
- **Respiration:** respiratory rate (normal range, 30–60 breaths/minute). Are there signs of respiratory distress (retractions, grunting, flaring, cyanosis, tachypnea)?
- **Circulation:** heart rate (normal range, 100-160 beats/minute). Is the periphery warm and well perfused?
- **Heat balance:** rectal temperature (target temperature, 36.5–37.5°C). Assessment of rectal temperature allows for early diagnosis of anal atresia.
- **Malformations:** extremities, genitalia, the back, palate. Placement of a gastric tube to exclude oesophageal atresia or upper intestinal obstruction is only warranted in case of polyhydramnios, foamy hyper-salivation, or respiratory distress. Routine probing of nasal airways to rule out choanal atresia should be avoided. All observations and measures need to be recorded on the baby's chart.
- The skin is cleared of all blood and meconium without completely wiping off the vernix.
- Vitamin K application, and active and passive hepatitis B vaccination[24] are performed according to current guidelines. Prophylactic silver nitrate or other disinfecting eye drops to prevent neonatal gonococcal ophthalmia are no longer recommended.

Procedures in Case of Impaired Adaptation

Resuscitation algorithm

If clinical assessment shows an absence of regular breathing or a heart rate below 100 beats/minute, further procedures are performed in addition to the aforementioned measures for a normal transition. Opening the airways and ventilating the lungs are the most important measures in neonatal resuscitation, and in most cases, these measures are sufficient to stabilise a neonate. Further, more complex interventions are ineffective if those two initial measures are not correctly established[5]. Potential steps and their respective indications are summarised in the *Algorithm*.

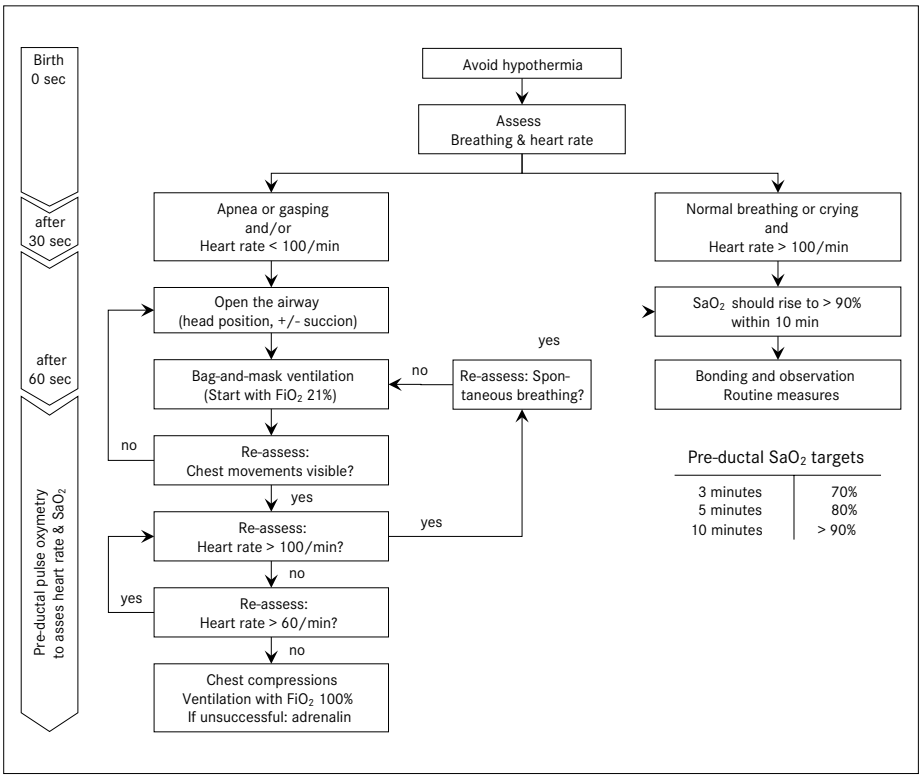


Table 2: Algorithm: Stabilisation and Resuscitation of the Newborn

Commentary on the Individual Steps

Heat balance

- Resuscitation should be performed in a heated room (target room temperature, 25–26°C)[3]. Draughts should be avoided; windows and doors should be closed.
- The radiant heater should be switched on 10–15 minutes ahead of the delivery.
- The infant should be quickly dried and transferred to the radiant warmer in warm blankets; wet blankets should immediately be replaced by dry and warm ones.

Correct Positioning *(Figure 1)*

- Correct horizontal supine placement of the infant, with the head in neutral position with slight extension, is important to maintain airway patency. Hyperextension or flexion of the head should be avoided, for this may lead to airway obstruction.
- A small bolster under the shoulders helps in maintaining airway patency.
- Positioning of the infant in a traditional Trendelenburg's position provides no advantages in terms of lung function, thus, it should no longer be performed[25].

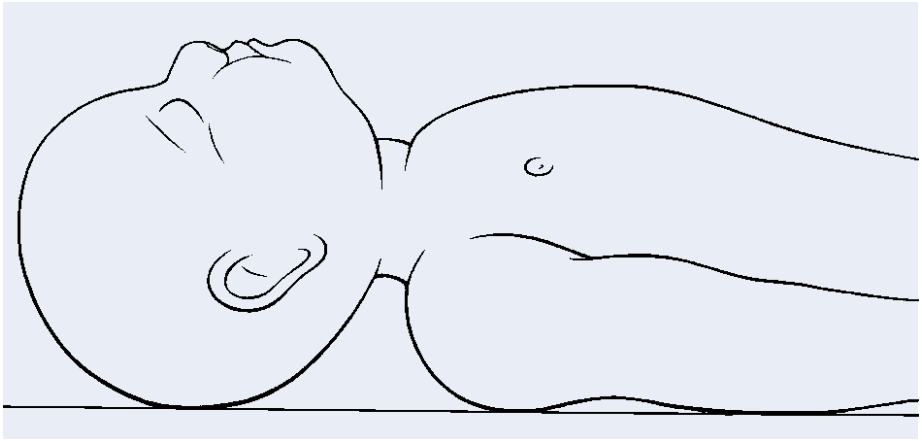


Figure 1: Correct positioning.

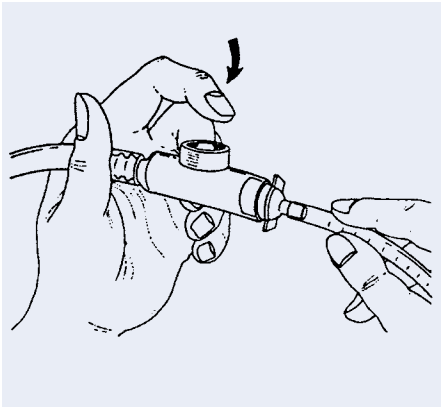


Figure 2: Meconium adapter for intratracheal suctioning.

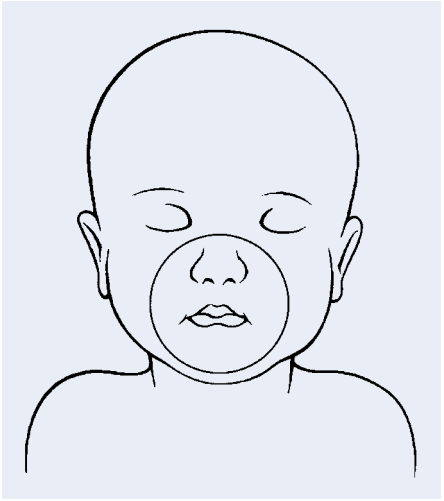


Figure 3: Correct positioning of the face mask.

Figure 4: Bag-and-mask ventilation. Caveat: The middle finger should be placed on the jaw without putting pressure on the floor of the mouth. Mouth is slightly opened.

Suctioning

- Use a 10 French (Fr) gauge catheter without side perforations. Use a suction device (oral suction device, mechanical suction device) with a trap (set negative pressure to about –2 m water column = –200 mbar = –150 mm Hg = –20 kPa = –0.2 atm).
- Suction the mouth and, if necessary, both nostrils.
- Do not insert the catheter into the nose because of risk of injury and swelling of mucous membranes. Newborn infants are obligate nose breathers.
- Caveat: Repeated suctioning of longer duration impedes development of spontaneous breathing. Touching the oropharynx can lead to a vagal reflex with bradycardia.
- Any suctioning manoeuvre should last less than 5 seconds. Suctioning of the stomach should only be performed when there is adequate oxygenation, stable respiration, and under the following circumstances:
  - In case of polyhydramnios, respiratory distress syndrome, or when foamy saliva is present.
  - After or during bag-and-mask ventilation or before a transport.
- If the catheter cannot be advanced into the stomach, oesophageal atresia is highly suspected. In that case the infant should be positioned prone, and mouth and pharynx regularly suctioned.
- Suctioning of more than 20 ml of gastric fluid is suggestive of upper gastrointestinal obstruction. In this situation, a feeding tube should be put in place, the end left open and suctioned every 10 minutes.
- Meconium-stained amniotic fluids: Intrapartum oropharyngeal suctioning has no influence on the outcome of the neonate [26)–28)]. Thus, this procedure is no longer recommended as a routine in newborns with meconium-stained amniotic fluid. In the rare situation of thick meconium obstructing the upper airways, intrapartum suctioning of the oropharynx may be beneficial.
- In case of thick meconium and depressed respiration, meconium should be suctioned laryngoscopically under direct vision prior to proceeding to bag-and-mask ventilation. Provided the care taker of the infant has the necessary skills and that relevant equipment is at hand, the infant should be intubated endotracheally. Tracheal suctioning is performed by directly connecting the meconium aspiration device between the endotracheal tube and suction source, then withdrawing the endotracheal tube under suction *(Figure 2)*. This procedure of intubation, tracheal suctioning, and extubation can be repeated provided the heart rate remains normal. Otherwise, one should proceed to efficient ventilation, especially with persistent bradycardia[3), 5)]. Suctioning with a catheter inserted through an endotracheal tube is usually not sufficient when thick meconium is present.

Bag-and-Mask Ventilation *(Figures 3 and 4)*

With insufficient or absent spontaneous breathing, or a heart rate <100/min, the newborn infant should be ventilated via bag-and-mask. The head is in midline, slightly extended, and the mouth is held minimally open. In term neonates, assisted ventilation is initiated with room air[3), 5)]. The first 5 inflations should be prolonged to 2–3 seconds in order to support aeration of the lungs. Inspiratory pressure is monitored using a manometer attached to the bag; often, an inspiratory pressure of 20–30 cm H_2O is sufficient. Occasionally, inspiratory pressures of 30–40 cm H_2O are required in term neonates. If monitoring of inspiratory pressure is not possible, inspiratory pressure should be adjusted such that an increase in heart rate is achieved[3), 5)]. Further ventilation is accomplished with pressures adjusted to the requirements of the infant (visible thorax

excursions, increase in heart rate?) and using a rate of 40–60/min. Although clinical studies specifically addressing the efficacy of positive end-expiratory pressure (PEEP) to establish functional residual capacity during initial resuscitation after birth are lacking, PEEP is likely to be beneficial and should be used if appropriate equipment is available. PEEP can be applied easily using a T-piece resuscitator. If a self-inflating bag is used, an additional PEEP-valve needs to be attached *(Figure 4)*[3].

Response to assisted ventilation is assessed by the following criteria:
- Visible thorax excursions.
- Most important sign of success: heart rate increases above 100/min.
- Skin complexion changes to pink.

Assisted ventilation is continued until the neonate establishes regular and sufficient spontaneous breathing. If continued bag-and-mask ventilation is necessary, a feeding tube should be inserted to allow shunted air to evacuate from the stomach[29]. The efficacy of a laryngeal mask airway has been shown in term newborn infants and in preterm infants ≥ 34 weeks GA and a birth weight > 2000 g[30), 31]. Thus, trained personnel, especially in situations where bag-and-mask ventilation or intubation have failed, can consider the laryngeal mask airway as an alternative for ventilating term newborn infants[b), 3), 5), 6), 32]. In most instances, however, bag-and-mask ventilation will be effective. Moreover, acquiring the skill of assisted ventilation is easier. If necessary, insertion of a Guedel tube can be considered (e.g. Pierre-Robin sequence, choanal atresia).

The Role of Oxygen in Newborn Resuscitation

Recent data question the use of pure oxygen (FiO_2 1.0) in newborn resuscitation, for lower oxygen concentrations or room air (FiO_2 0.21) have proven just as effective as oxygen in high concentrations[33)–36]. There is concern with regard to the possible effects of applying 100% oxygen on respiration, cerebral perfusion, and due to the potential cell-damaging effects caused by oxygen radicals, especially when high concentrations of oxygen are given following a hypoxic event associated with cell and tissue injury. In general terms, oxygen ought to be considered a medication whose indication and dosage should be strictly regulated. The large majority of newborn infants do not require supplemental oxygen immediately after birth. Isolated peripheral cyanosis in an otherwise vigorous newborn with normal heart rate is not an indication for supplemental oxygen application.

Recent data show that preductal transcutaneous oxygen saturation during normal transition in healthy term neonates rises from 40–60% to > 90% within 10 minutes after birth *(Algorithm)*[37)–42]. Oxygen should be dosed properly and always be monitored via preductal transcutaneous pulse oxymetry ($tcSaO_2$). Target $tcSaO_2$ under supplemental oxygen should be 90–95% (increase FiO_2 if $tcSaO_2$ < 90%, decrease if $tcSaO_2$ > 95%).

Neonates not requiring resuscitation

In case of inadequate oxygen saturation *(Algorithm)*, or when a newborn infant has central cyanosis after 5 minutes of life associated with regular breathing and normal heart rate, the infant should be stimulated and administered oxygen via a face mask (flow 4–5 L/min, initial FiO_2 0.30–0.40). The face mask should be placed evenly over mouth and nose with a proper seal. Unnecessary movements back and forth of the mask will lead to fluctuations in oxygen concentration. Oxygen concentration is increased stepwise in increments of 10% until a normal oxygen saturation is obtained.

Neonates requiring resuscitation

Assisted ventilation in term neonates should be initiated with room air. If a neonate shows insufficient breathing in presence of a normal heart rate, inspired oxygen concentration should be adjusted depending on $tcSaO_2$ (measured by preductal pulse oxymetry). If cyanosis persists in presence of a normal heart rate, supplemental oxygen should be titrated such that oxygen saturation increases normally *(Algorithm)*[c), d), 3), 5]. On the other hand, if bradycardia persists despite adequate ventilation for 30 seconds, supplemental oxygen concentration should be increased to 100% within a short period.

Endotracheal Intubation *(Figure 5, Table)*

If heart rate remains below 100 beats/min after 30–60 seconds of adequate assisted ventilation, or if there is absent spontaneous breathing or persistent cyanosis, the infant is intubated endotracheally. The indication for intubation depends on the clinical situation (e.g., diaphragmatic hernia), degree of respiratory depression, gestational age, efficacy of bag-and-mask ventilation, and finally the experience of the operator. Only a trained person should perform an intubation. Oro-tracheal intubation is more rapid and easier to perform than naso-tracheal intubation, and this should therefore be the preferred method to overcome acute hypoxaemia and/or bradycardia. Nasal intubation permits better fixation in case of a potential transport, but technically it is more challenging than oro-tracheal intubation and should not be undertaken in case of acute hypoxaemia. If the person doing the resuscitation is not trained in intubation, bag-and-mask ventilation should be continued until a person skilled in neonatal intubation

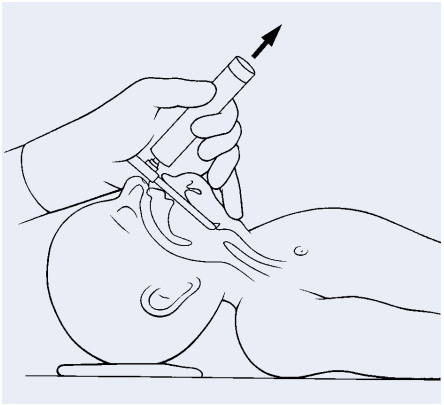


Figure 5: Oro-tracheal intubation.

b) But not for preterm infants (< 34 wks GA, < 2000g BW), not during chest compressions, and in newborn infants with depressed respiration born with thick meconium.

c) Based on animal experimental data, newborn infants with pulmonary hypertension or with malformations such as pulmonary hypoplasia (oligohydramnios, diaphragmatic hernia) might profit from higher oxygen concentrations. But data are too scarce to be able to make general recommendations for that purpose[41].

d) Hyperoxaemia is harmful for preterm infants and can occur at oxygen saturation values > 95%. For this reason, the postnatal increase in oxygen saturation in preterm infants should not exceed the rise seen in term infants. Although the data are not fully clear yet, additional oxygen immediately after birth may be necessary and advantageous in preterm infants[43)–45]. The use of a pulse oximeter should be considered in every delivery when a disturbed adaptation, respiratory support or need for resuscitation can be expected for a newborn infant[6]. Modern devices allow a reliable and continuous assessment of the oxygen saturation and heart rate from the first minutes of life[46]. The sensor is applied to the right hand or right lower arm thereby allowing a precise measurement of the preductal oxygen saturation[39), 42]. A faster signal acquisition can be obtained by applying first the sensor to the infant, and afterwards connecting it to the device; with this sequence a reliable measurement can be obtained in most cases within 90 seconds[47].

arrives on the scene. During intubation the heart rate should be monitored. An intubation should be interrupted in case of bradycardia, or in case of an unsuccessful attempt, after 30 seconds at the latest.

Correct positioning of the endotracheal tube must be verified after each intubation. In most cases, this can easily be accomplished by clinical assessment (visually during intubation, rapid rise of heart rate and oxygen saturation, humidity in the tube, thorax excursions, symmetrical air entry on auscultation of the lungs). Measurement of expiratory CO_2 concentration (e.g., using a colorimetric device) is easy and rapidly achieved; it is the gold standard of confirming endotracheal intubation[e), 3), 5), 48)].

Extubation in the Delivery Room

Preterm infants intubated right after delivery should remain so for transport to the neonatal unit. In rare circumstances, term neonates may be extubated in the delivery room if the cardio-pulmonary situation has normalised, the infant is pink (pulse oxymetry) and blood gas analysis is normal. With an endotracheal tube in place, the infant should be ventilated at all times, and a PEEP of 5 cm H_2O should be applied. Atelectasis may occur if an infant breathes spontaneously through an endotracheal tube without application of PEEP.

Therapeutic Hypothermia

Neonates ≥ 36 0/7 weeks GA with severe metabolic acidosis (pH < 7.0, obtained from umbilical artery or blood gases within first hour of life; base deficit > -16 mmol/L) and clinical evidence of moderate to severe hypoxic ischaemic encephalopathy should be treated with therapeutic hypothermia[49)]. This significantly improves survival and neurological outcome[50)]. Such treatment should, however, only be performed in a neonatal intensive care setting using strict criteria and rigorous protocols[5)]. The therapeutic window is open within the first 6 hours after birth; after contacting and in agreement with the receiving neonatal centre, external heat sources may be shut down and the neonate may be undressed in the referring hospital prior to arrival of the transport team[51)]. These measures should not impair initial resuscitation and stabilisation of the neonate, they are, however, important for further care of the child[5)]. No active cooling measures should be installed (e.g., ice packs) given that these may lead to rapid hypothermia. Rectal temperature should be measured every 15 minutes until arrival of the transport team. Target temperature is 34–35°C. If rectal temperature falls below 34°C, the infant should be covered with a cloth and temperature measurement should be repeated after 15 minutes. Cooling during transport is performed according to the national cooling protocol (https://www.neonet.unibe.ch/forms_full_asp.html).

e) No data exist regarding the measurement of expiratory CO_2 in neonatal resuscitation. Nevertheless and besides the clinical assessment, the proof of CO_2 in the expiratory air represents a useful method to confirm the intratracheal position of the endotracheal tube[3), 5)]; whereas a negative result indicates an esophageal intubation. The result of this measurement can be false negative in case of low lung perfusion. Contamination of the colorimetric device with surfactant, adrenalin or atropine can lead to a false positive result[6)]. In this case however and in contrast to a successful intubation, the color signal does not change synchronously with in- and expiration.

Volume Expansion and Buffering

Venous Access

In case of intubation or cardiopulmonary instability, intravenous access is mandatory in neonates. In urgent cases or when the infant is in shock, umbilical catheterisation is the best option *(List 1)*. Once the cardiovascular system has been stabilised, continuous infusion with Glucose 10% is begun at a rate of 3 ml/kg/h, which corresponds to a glucose supply of 5 mg/kg/min.

Volume Expanders

If signs of hypovolaemia or cardiovascular compromise are present (as indicated with poor peripheral perfusion, week pulses, pallor, and tachycardia), volume expansion must be applied over 5–10 minutes. The following solutions come into consideration:

- NaCl 0.9% or Ringer's Lactate (initial dose 10 ml/kg, to be repeated depending on blood pressure and clinical signs).
- Packed Red Blood Cells (in case of acute anaemia, use untested O Rh negative blood). Dosage: 10 ml/kg, to be repeated if necessary.

Albumin 5% is no longer recommended as a volume expander for neonatal resuscitation[52)].

Buffering

In the presence of metabolic acidosis, the aim is to treat the primary cause. Sodium bicarbonate administration can lead to significant side effects (paradoxical intracellular acidosis, osmotically induced myocardial dysfunction, diminished cerebral perfusion, and cerebral haemorrhage especially in preterm infants). There is no evidence for the efficacy of sodium bicarbonate in initial resuscitation of a neonate, and it is no longer recommended in the initial phase of resuscitation[6), 53)–56)].

Chest Compressions *(Figures 6a–c)*

Adequate ventilation is the most important measure in initial resuscitation of the neonate; if assisted ventilation is insufficiently performed, chest compressions will be ineffective[5)]. Chest compressions are very rarely necessary in neonatal resuscitation (<1:1000 deliveries).

Indications for chest compressions include:

- Absent heart sounds (asystoly)[f)].
- Bradycardia less than 60 beats/min despite adequate ventilation with a FiO_2 of 1.0 for 30 seconds.

Compression technique: Both thumbs are placed side by side or superimposed beneath a virtual line drawn between both nipples *(Figures 6a and 6b)*, with fingers encircling the thorax. Compression depth should be at least 1/3 of the antero-posterior diameter of the thorax *(Figure 6c)*. Chest compressions can impede effective ventilation, which is why both actions should be coordinated, to avoid simultaneous delivery[3), 5)]. There should be a 3:1 ratio of compressions to ventilations during the neonatal period (up to 4 weeks post expected date of delivery), to achieve 90 compressions and 30 breaths per minute; assisted ventilation should be performed with 100% O_2. Heart rate should be measured 30 seconds after initiation of cardiac massage and be re-evaluated in 30 second intervals. Cardiac massage can be stopped when spontaneous heart rate is > 60 beats/minute[5)].

Discontinuation of Resuscitation

If despite continuous and appropriate resuscitative efforts over 10 minutes the newborn infant does not show any vital signs (no cardiac activity, no spontaneous breathing), discontinuation of resuscitation may be justified, for survival becomes very unlikely or is most likely associated with severe disability[3), 6), 57), 58)]. In case of uncertainty, resuscitation should be continued until a person trained in

f) Assessment of heart rate by auscultation with a stethoscope, by feeling for pulsations at the base of the umbilical cord. The use of a pulse oximeter or of an ECG under chest compression makes sense and is helpful.

Figure 6a: Chest compressions (both thumbs placed side by side). Caveat: Thumbs should be flexed at the distal joint to enable vertical pressure on the thorax and thereby compression of the heart between sternum and vertebral column.

Figure 6b: Chest compressions (thumbs superimposed).

Figure 6c: Chest compressions (compression phase). Caveat: Apply sufficient pressure in order to reduce the antero-posterior thorax diameter by a third.

neonatal resuscitation arrives on the scene and a concerted evaluation should be performed before discontinuing resuscitative efforts. After discontinuation the person in charge should contact the neonatal unit to arrange potential further exams.

Care of the neonate following resuscitation

The condition of neonates requiring resuscitation after birth may deteriorate again at a later stage. Therefore, after establishing adequate spontaneous ventilation, oxygenation, and circulation, these infants should be transferred to a setting allowing for continuous monitoring and care[3), 5)].

Laboratory Tests in the Delivery Room

Clinical assessment of adaptation can be complemented by the following 'laboratory-triad':

- Blood gas analysis
- Haematocrit
- Blood sugar level

Blood gas analysis is necessary if umbilical artery pH is < 7.15 and in the presence of clinical signs of abnormal adaptation.

Haematocrit should be determined when suspecting polyglobuly (post term, dysmaturity, or peripheral cyanosis) or anaemia (pallor, circulatory instability).

In the delivery room, *blood glucose levels* are determined only if symptoms suggestive of hypoglycaemia are present, or in case of diabetic foetopathy. Low blood glucose levels are common during early postnatal transition. Thus, measurements of blood glucose levels within the first 2–3 hours of life in asymptomatic newborn infants are misleading and clinically meaningless[59)]. Aim for normal blood glucose levels in neonates with hypoxic-ischaemic encephalopathy (3.0 to 4.5 mmol/L)[60)].

Postnatal Transport of High Risk Newborn Infants

Whenever possible a postnatal transport should be avoided. Instead, one should strive for a prenatal transfer of the pregnant mother to a perinatal centre with a neonatal intensive care unit.

Indications for Transport of Newborn Infants to a Neonatal Unit:

- Preterm infant below 34 0/7 to 35 0/7 weeks GA.
- Birth weight less than 2000 g.
- Severe metabolic acidosis (pH < 7.0, obtained from umbilical artery or blood gases within first hour of life; base deficit > -16 mmol/L) independent of clinical situation.
- Neonates ≥ 36 0/7 weeks GA with clinical signs of moderate to severe hypoxic ischaemic encephalopathy eligible for therapeutic hypothermia (contact the receiving neonatal centre within 6 hours of birth).
- Resuscitated infant (assisted ventilation > 5 min, intubation, chest compressions, volume expansion, medication etc.).
- Cardio-pulmonary disturbances lasting more than 3 to 4 hours post delivery.
- Persistent or recurrent hypoglycaemia (<2.5 mmol/L with a bedside test) despite early feeds[59)].
- Suspected neonatal infection (no antibiotics to be given orally or intramuscularly)[61)].
- Seizures, symptoms of drug withdrawal.
- Jaundice at birth[62)].

This list is not exhaustive; special cases should be discussed with the perinatal/neonatal centre. Newborn infants should be transported by trained neonatal transport teams using transport incubators.

Checklist before transport:

- Mother's and infant's data, resuscitation flow sheet.
- Maternal blood (10 mL EDTA blood) and cord blood.
- Placenta.
- Call neonatal unit before departure.
- Suction infant's mouth and stomach before transport, insert gastric tube.
- Show infant to mother or both parents if possible before departure.
- Provide the parents with the address and telephone number of the neonatal ward.

Care of the Parents

Parental support during the delivery is an important task that is particularly challenging when the newborn infant shows an abnormal adaptation or is born with malformations. Resuscitation often requires an ample amount of attention, thus impeding mother-infant interaction. Nevertheless, parent-infant contact should be encouraged at all times, even in difficult situations.

Most parents witnessing a resuscitation experience fear and negative feelings. In the immediate acute situation, resuscitation efforts cannot be explained and discussed with the parents. It is thus more desirable to resuscitate the infant in a different room, without the parents. The best-case scenario is to brief the parents before delivery on possible postnatal complications and on their appropriate management. Parental presence during a possible resuscitation can also be discussed at that time.

Even after a difficult resuscitation, there should be sufficient time for parental briefing,

and for the parents to see and touch their child. Before transferring the infant to the neonatal centre, his/her picture should be taken and handed over to the parents. The parents should also receive the address and telephone number of the neonatal ward as well as the name of a contact person. Mother and nurses need to be reminded that the milk production should be stimulated by regular pumping even in a crisis situation.

List 1

Equipment for a Delivery in a Hospital Setting

Inventory of the Resuscitation Equipment
- Mobile or fixed resuscitation unit.
- Radiant warmer, warm and draught-free environment.
- Connections for electricity, oxygen/ compressed airg) and suction.
- Work surface and space for material.
- Stop watch/Apgar timer.
- Access for the transport incubator.

Lighting
- Bright light, preferably integrated within the radiant warmer.

Heat Source
- Overhead (constant height) controllable radiant warmer with a fixed distance to the pad (do not use red light heater).
- Sufficiently warmed blankets/diapers (do not use electric blankets).
- Preheat resuscitation place early enough.

Suction Device
- Mouth-held suction device.
- Suction device with negative pressure set at –200 mbar (-20 kPa, ca. - 0.2 atm, -2 mH_2O, -150 mmHg).
- Suction catheter and tubing connectors.
- Meconium adaptor for intratracheal suctioning.
- Suction catheter sizes 6, 8 and 10 Ch.

Oxygen and Gas Supply
- Oxygen source with flow meter, compressed air/oxygen blenderg), tube to face mask/ ventilation bag.
- Compressed air.
- Pulse oximeterh).
- Oxygen face mask.

Equipment for Ventilation
- Ventilation bag with a reservoir and a peep-valve; plus one extra bag in reservei).
- Face masks of silicon (sizes 00 and 01); plus one extra set in reserve.
- Laryngoscope, blade sizes 0 and 1; plus additional bulbs and batteries.
- Endotracheal tubes: sizes 2.5/3.0/3.5 (mm internal diameter) for oral and nasal intubation, plus guide wire.
- Magill forceps.
- Adhesive tape.
- Stethoscope for infants.
- Guedel tube sizes 00/000.

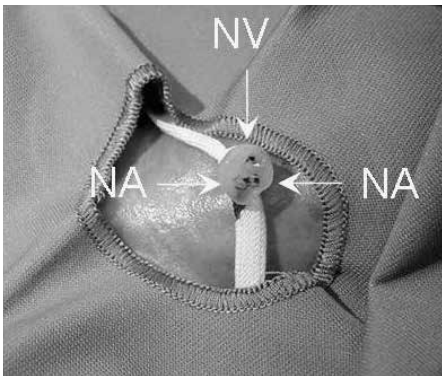
Material for Venous Access

Peripheral Lines
- Butterfly catheters 25 and 27 G; venous in-dwelling catheters 24 and 26 G.
- Three-way stopcock.
- Extension (special paediatric size).
- Band-aid.
- Splint.
- 10 ml, 5 mL, 2 mL and 1 mL syringes; 5 syringes for each size.
- Needles (18 G, 1.2.x 40 mm, pink).

Umbilical Venous Catheter
- Sterile gloves, different sizes.
- Disinfectant (containing either alcohol or octenidin-phenoxyethanol), sterile swabs.
- Sterile umbilical tray: Umbilical tape, sterile drape with open hole, 2 Péan clamps (haemostats), fine and rough anatomical forceps, scissors, needle holder) (optional), scalpel, suture (4.0, eventually with atraumatic needle).
- Umbilical vein catheter 3.5 and 5 Ch.

Umbilical Vein Catheter Placement

1. Have assistant hold umbilical cord up.
2. Disinfect skin and umbilical stump.
3. Place sterile drape on the infant with open hole over the cord stump, still allowing for infant to be observed.
4. Place sterile umbilical tape around the cord stump with a loose knot.
5. Using the sterile blade, cut off cord stump 1 cm above the skin of the umbilicus.
6. Locate the umbilical vein and the 2 umbilical arteries.
7. Using haemostats (Péan clamps) to stabilise the stump, clamp the Wharton's Jelly and insert the catheter (usually 5 Ch), which has been flushed with 0.9% NaCl beforehand, into the vessel lumen.
8. The catheter should be advanced to the appropriate depth according to the size of the infant. In an emergency situation, a depth of 4–5 cm is sufficient (check by aspirating blood).
9. Suture catheter to Wharton's Jelly (thread 4.0, don't suture to the skin), this is ideal in case of a transport. If the child will not be transported, the catheter may be secured to the abdominal skin using thread and Steristrip tape.



Further Equipment
- Umbilical cord clamps.
- Gastric tubes, sizes 6 and 8 Ch.
- Venous in-dwelling catheters 18 and 20 G (for drainage of a pneumothorax).
- Apgar timer (possibly a stop watch).

g) Every resuscitation unit (as opposed to simple infant warmers in delivery rooms) is equipped with it's own oyxgen/compressed air outlet, as well as an oxygen blender and a pulse oximeter.

h) Transcutaneous oxygen saturation measurements to monitor oxygen application should always be preductal by applying the sensor to the right hand or right lower arm. This is in contrast to the later measured postductal SaO_2 to rule out congenital heart defects[63].

i) Adequately trained personal can also use a T-piece resuscitator on the resuscitation unit. Because this device needs a good instruction and a regular use to be applied safely and efficiently, it is mandatory to always have a ventilation bag with the necessary equipment on each resuscitation unit.

Endotracheal Tube			2 kg 34 wks GA	3 kg 37 wks GA	4 kg 40 wks GA
Tube size			ID 3.0	ID 3.5	ID 3.5
Insertion depth at lip (cm)			8	9	10
Insertion depth at nose (cm)			9.5	10.5	11.5
Medication	**Dose**	**Preparation/Indication**	**2 kg 34 wks GA**	**3 kg 37 wks GA**	**4 kg 40 wks GA**
Adrenalin 1 : 1000 (1 mg/mL vial)	Intravenous dose: 10–30 mcg/kg IV	1 mL + 9 mL NaCl 0.9% (1 : 10 000 i. e. 1 mL = 100 mcg)	0.2–0.6 mL	0.3–0.9 mL	0.4–1.2 mL
	Intravenous dose: 50–100 mcg/kg i. tr.		1–2 mL	1.5–3 mL	2–4 mL
NaCl 0.9% Ringer's Lactate	10 mL/kg	Volume bolus	20 mL	30 mL	40 mL
Glucose 10%	4–6 mg/kg/min 2 mL/kg	Glucose Infusion Symptomatic hypoglycaemia	6 mL/h 4 mL	9 mL/h 6 mL	12 mL/h 8 mL

- Tape measure.
- Thermometer.

Fluids

- 10% Glucose, 100 mL bottles and 10 mL vials.
- 0.9 % NaCl, 100 mL bottles and 10 mL vials or Ringer's Lactate 100 mL bottles.

Drugs (Table)

Drugs are rarely needed for neonatal resuscitation; volume expanders or adrenalin are primarily used (epinephrine)[3), 6)]. Bradycardia after delivery is usually caused by inadequate ventilation or severe hypoxia[5)]. Thus, drugs should only be considered after proper assisted ventilation is established[46)].

Adrenalin 1:1000 (1 mg/mL)[j)]

If the heart rate remains below 60 beats/min despite adequate ventilation with 100% oxygen and chest compressions for at least 30 seconds, administration of adrenalin is reasonable[5)]. Intravenous dosage: 10–30 micrograms/kg/dose IV (corresponds to 0.1–0.3 mL/kg of a 1:10000 adrenalin solution; 1 mL of a 1:1000 adrenalin solution + 9 mL of 0.9% NaC[j)]. Intratracheal dosage: 50–100 micrograms/kg/dose[3), 5)].

j) No studies of high dose adrenalin application (100 µg/kg/dosi) in newborn infants exist[56)]. For this reason and because of potential side effects, this dosage is not recommended. Although in neonatal resuscitation the intubation is usually performed before a venous access (umbilical venous catheter) is placed, the intravenous application of adrenalin should be preferred to the intratracheal route whenever possible. If adrenalin is given repeatedly intravenously, the normal dosage should be chosen[3), 5)].

Naloxone (0.4 mg/mL)

There is no evidence to support the use of naloxone to reverse neonatal respiratory depression caused by opioids. Furthermore, it is unknown if naloxone can reduce the need for mechanical ventilation in the delivery room. Long-term safety is questionable, too; therefore, naloxone cannot be recommended routinely in respiratory-depressed newborn infants in the delivery room[64)]. First line treatment includes respiratory support and mechanical ventilation. Possible indication: Newborn infants whose mothers have received opioids within 4 hours of delivery. Dosage: 0.1 mg/kg IV or IM (not to be given endotracheally or subcutaneously)[k)]. The half-life of naloxone is usually much shorter than that of opioids, which is why infants must be monitored during the first 24 hours after its administration.

Contraindication: Infants of opioid dependent mothers (check history!).

Caveat: Naloxone-Neonatal (0.02 mg/mL) should no longer be used.

List 2

Minimally Required Equipment for a Home Birth

- Telephone connection (numbers of ambulance and closest hospital at hand).
- Heated room and good lighting conditions.
- Table with padded surface on table height.
- Towels and gloves.
- Mouth-held suction device.
- Ventilation bag (e.g. Baby-Ambu or Laerdal-bag, with oxygen reservoir) as well as masks (Laerdal masks sizes 00 and 01).
- Oxygen face mask and oxygen connecting tube.
- Oxygen bottle with a flow meter (flow of up to 6–10 L/min).
- Plastic wrap.
- Pulse oximeter.
- Resuscitation flow sheet.
- Cord clamp, cord scissors.
- Stop watch/Apgar timer.
- Stethoscope.
- Thermometer.
- Bedside blood glucose measuring device.

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k) The AAP recommended dosage of Naloxone of 0.1 mg/kg is not evidence based[65)].

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